COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

PHENIX

Full jet reconstruction in $p + p$ collisions at $\sqrt{s} = 200$ GeV in PHENIX

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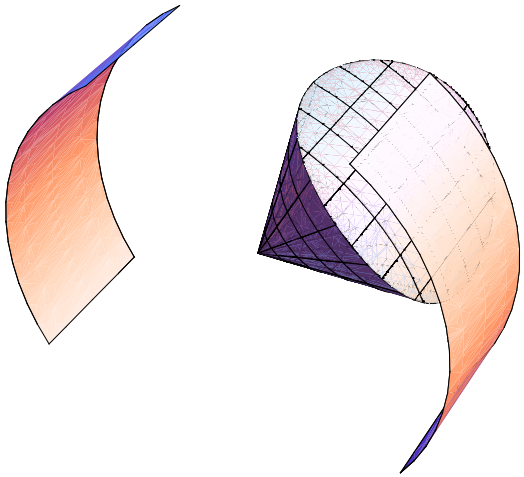
Columbia University and Nevis Laboratories/PHENIX Collaboration

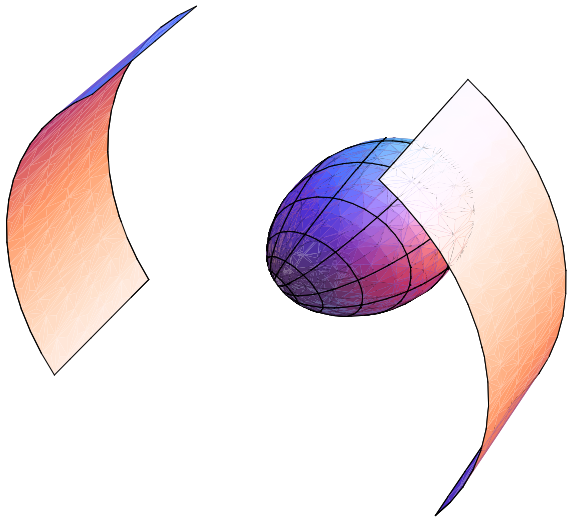
DNP08, Session MD

Jet reconstruction as convolution

- Convolution is a generalization of the cone algorithm (without merge/split)



"Cone" $R = 0.5$



Gaussian kernel $\sigma = 0.5$

- Gaussian filter:

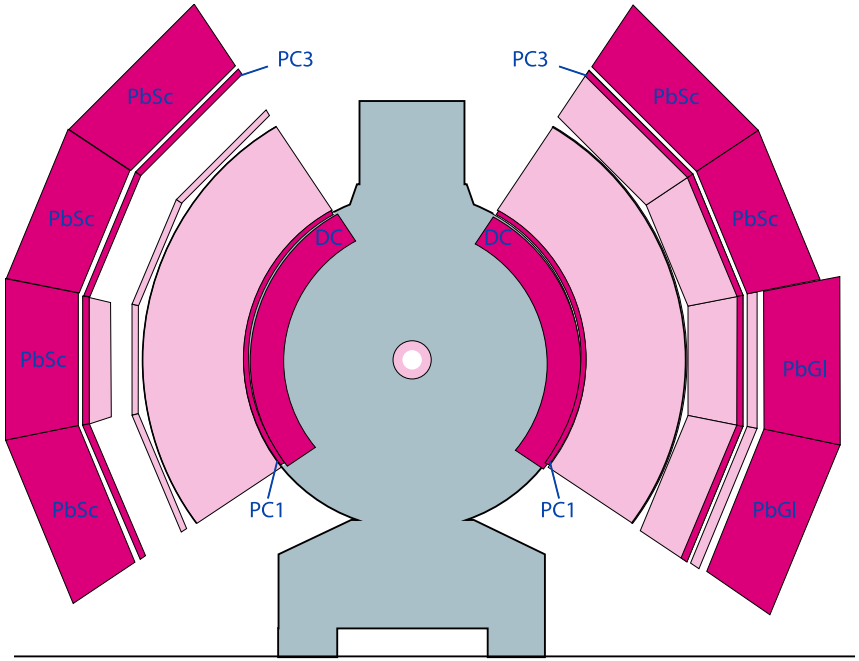
$$\tilde{p}_T(\eta,\varphi) = p_T \circledast h \equiv \iint_{\mathbb{R}\times S^1} d\eta' d\varphi' p_T(\eta',\varphi') h(\eta-\eta',\varphi-\varphi') = \text{max!}$$

$$h(\eta,\varphi) = e^{-(\eta^2+\varphi_{\text{ar}}^2)/(2\sigma^2)}$$

Why Gaussian filter

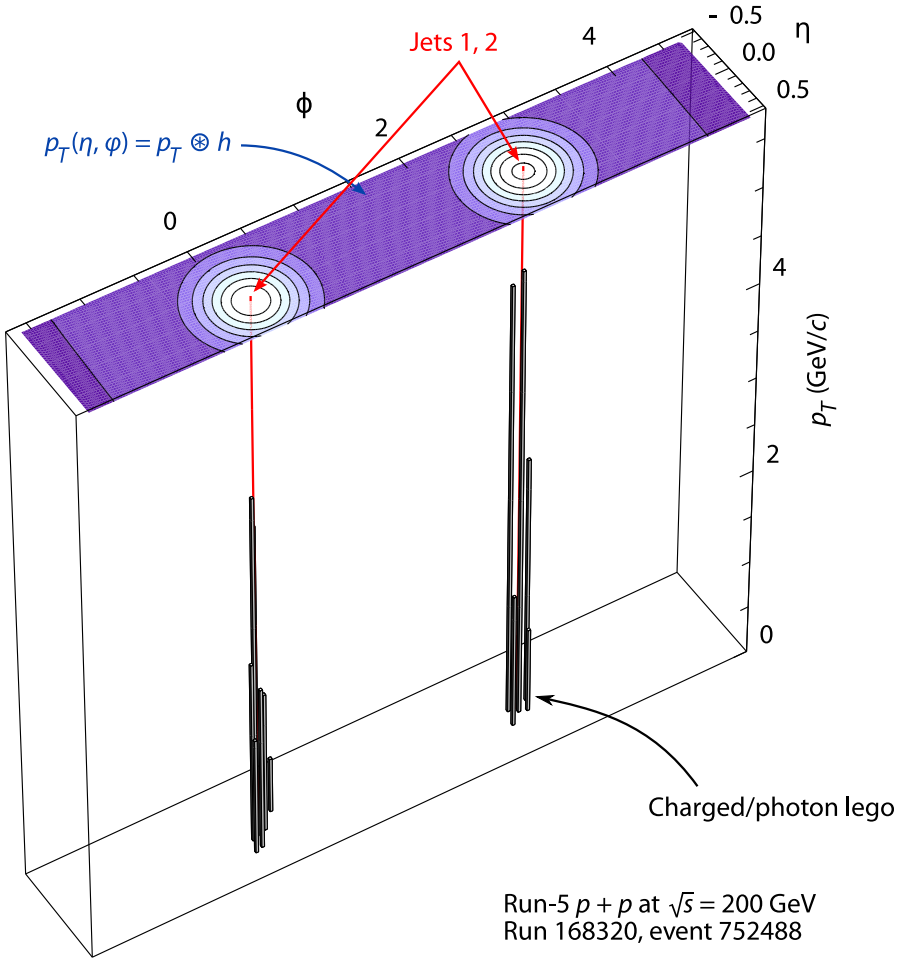
- Generalized cone algorithm – preserves the "cone"-like property
- Naturally collinear and infrared safe
- Smooth angular cut-offs for finite acceptance – e.g. PHENIX Central Arm
  - $-0.35 < \eta < 0.35$
  - $-0.59 < \varphi < 0.98, 2.16 < \varphi < 3.73$
- Generalizable to central Au + Au at $\sqrt{s_{NN}} = 200$ GeV while having
  - fake jet rate sufficiently low to measure jet quenching
  - near unitary efficiency for the most RHIC-accessible jet energy range
- Fast, for central Au + Au at $\sqrt{s_{NN}} = 200$ GeV multiplicity:
  - $\approx 1.9\times$ reconstructed event/s of Fast k_T
  - $> 30\times$ reconstructed event/s of SISCone
- Partially inspired by the energy flow observable $\bar{f}_{\bar{\Omega}_c}$ in C. F. Berger, T. Kucs, G. Sterman, Phys. Rev. D **68**, 014012 (2003); G. Sterman, hep-ph/0501270
- Study for $p + p$ collisions: arXiv:0806.1499, paper regarding the heavy ion study is coming soon

PHENIX Run-5



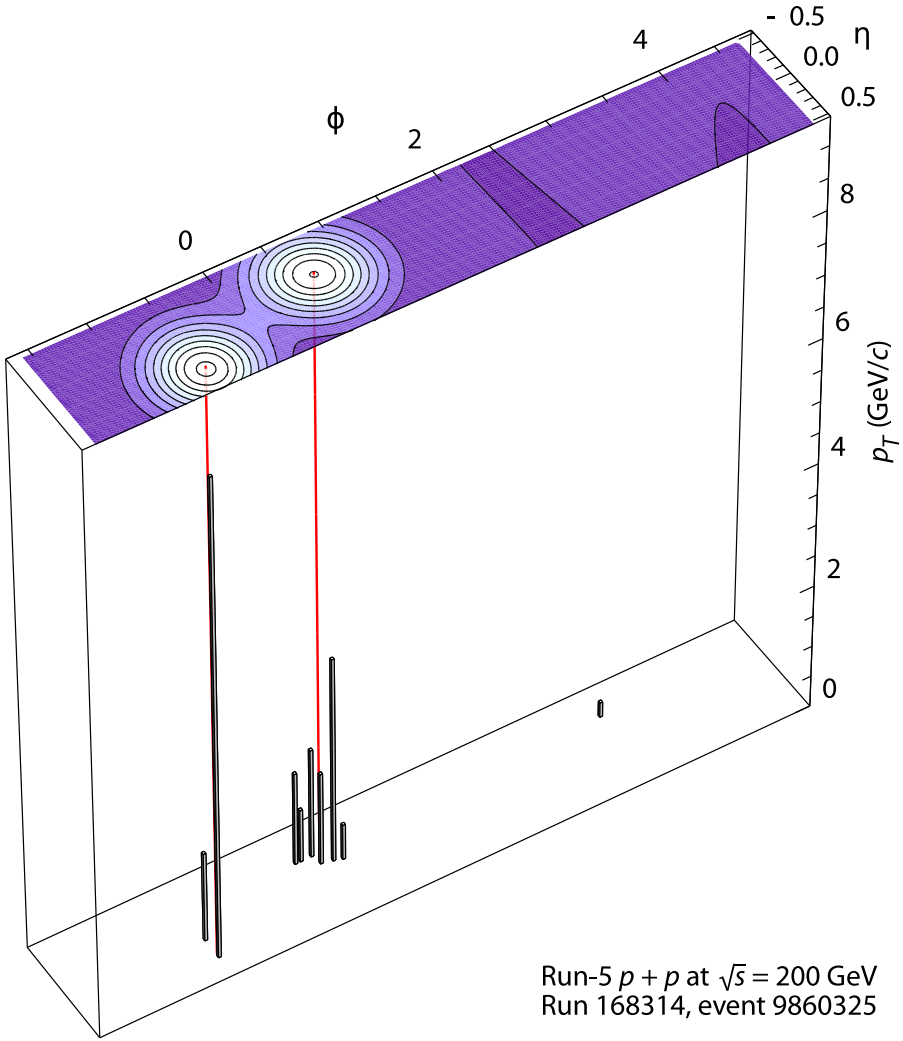
- Data set: PHENIX Run-5 $p + p$ at $\sqrt{s} = 200\,\text{GeV}$
  - Tracking detectors: Drift Chamber (DC), Pad Chambers (PC) 1/3
  - Calorimeters: Lead-Scintillator (PbSc), Lead-Glass (PbGl)
- Gaussian kernel with $\sigma = 0.3$
- Jet reconstruction cuts for background suppression:
  - ≥ 3 particles in a 60° cone
  - $\max z < 0.95$

Event display (PHENIX data)



- Top: filter density contour
- Bottom: (charged and neutral) p_T Lego plot
- Red line: jet axes

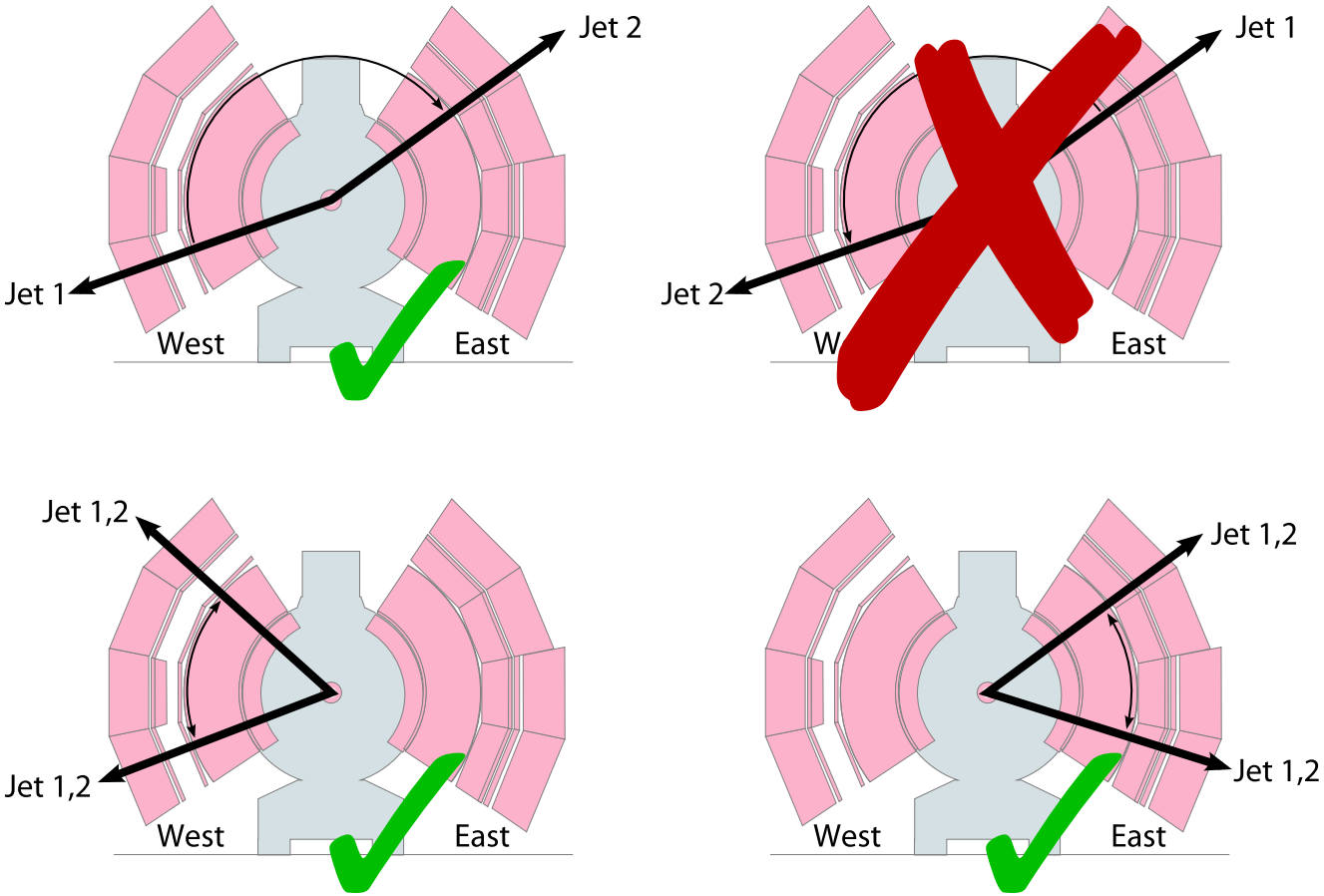
Event display (PHENIX data)



Run-5 $p+p$ at $\sqrt{s} = 200$ GeV
Run 168314, event 9860325

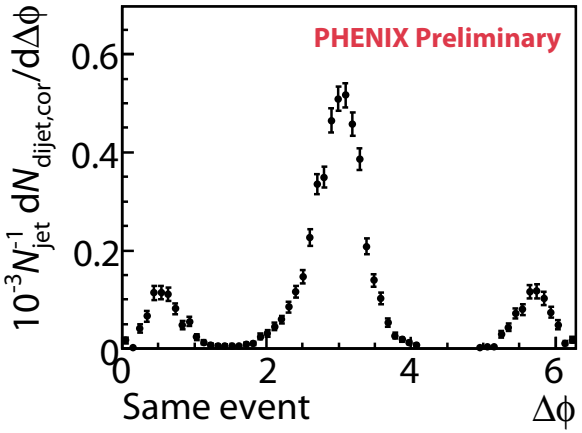
- Top: filter density contour
- Bottom: (charged and neutral) p_T Lego plot
- Red line: jet axes

Unsymmetrized correlation

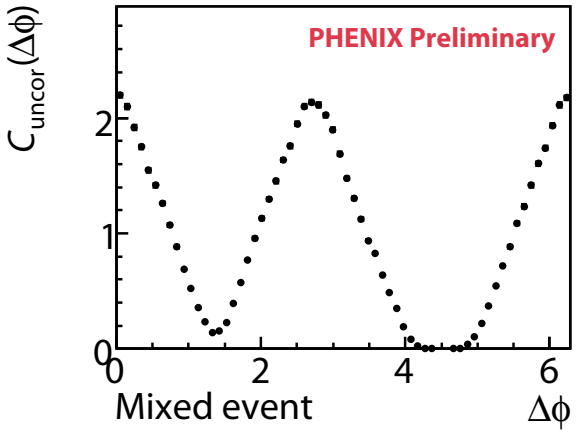


- Unsymmetrized, one-sided correlation to show the full PHENIX azimuthal acceptance effect

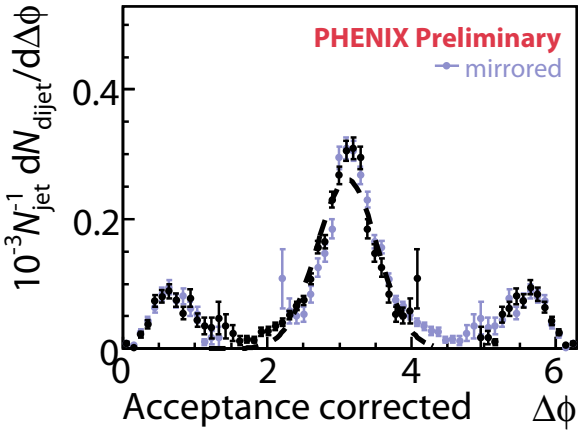
Jet–jet correlation, symmetric $4 < p_{T,\mathrm{jet,rec}} < 6$ GeV/c



Run-5 $p+p$ at $\sqrt{s} = 200$ GeV



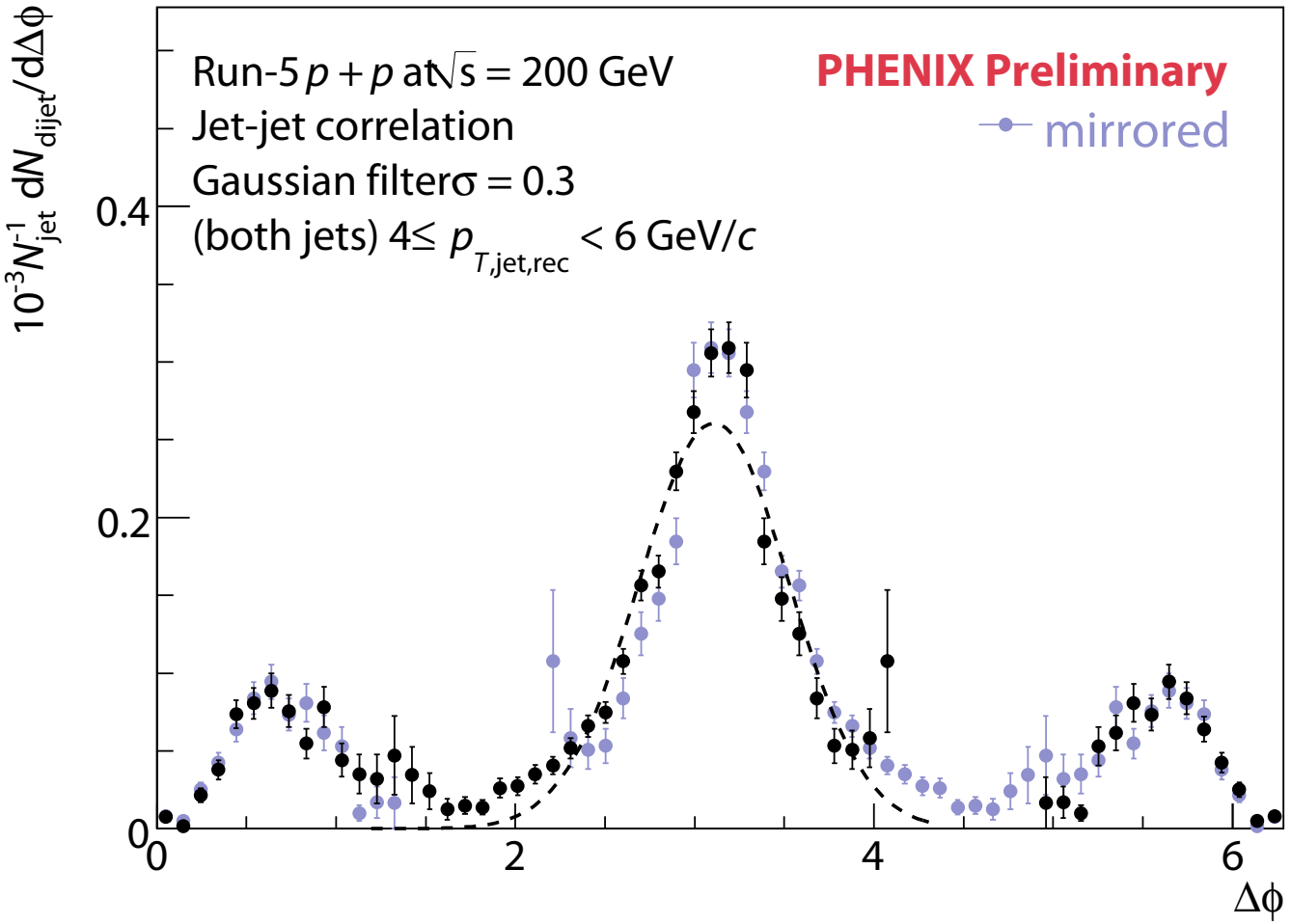
Jet-jet correlation, $\sigma = 0.3$



(both jets) $4 \leq p_{T,\mathrm{jet,rec}} < 6$ GeV/c

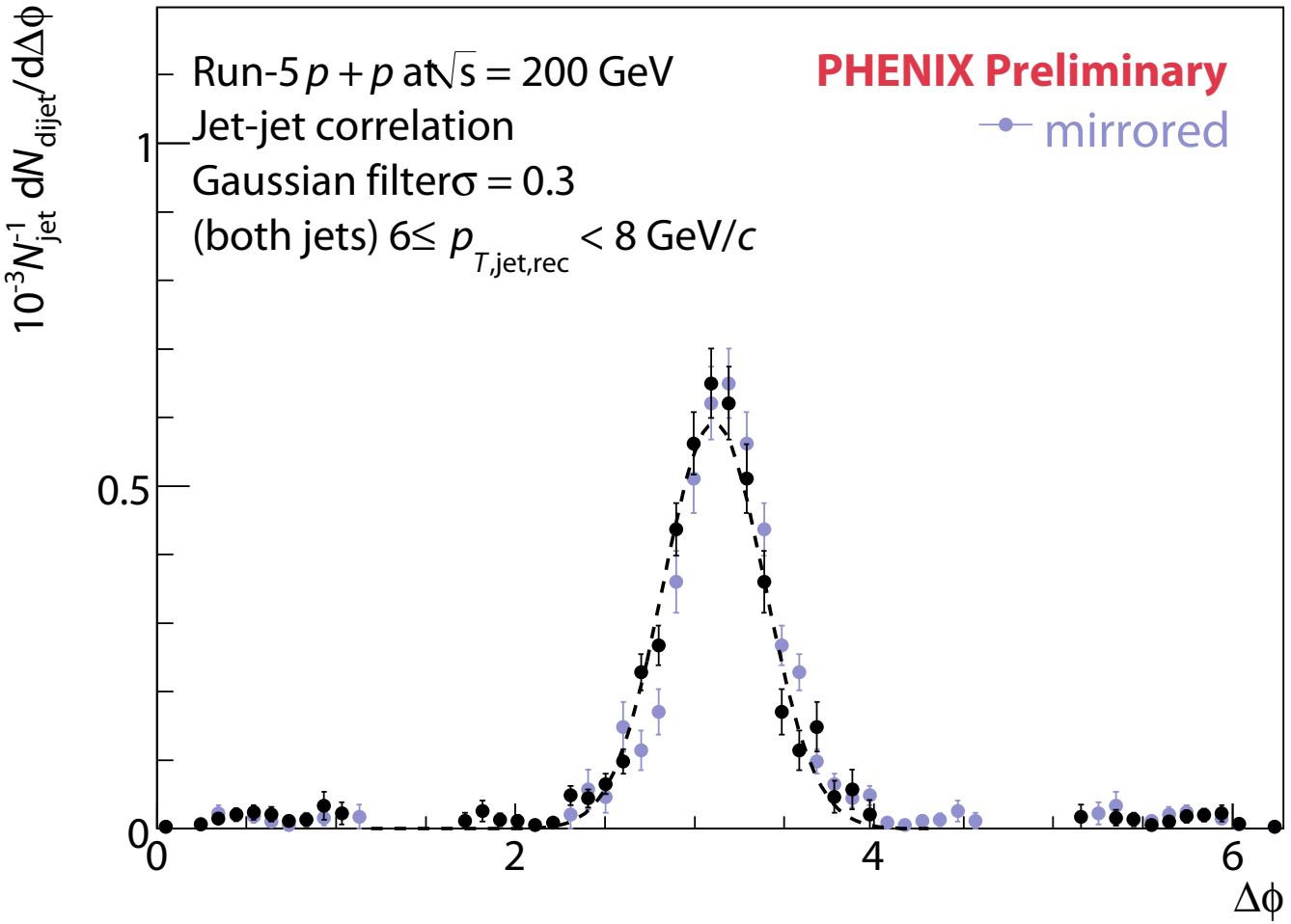
- We recover a uniform azimuth acceptance by dividing same-event by mixed-event jet–jet correlation
- Correlation function is symmetric even with unsymmetrized PHENIX acceptance

Jet–jet correlation, symmetric $4 < p_{T,\mathrm{jet,rec}} < 6\ \mathrm{GeV}/c$



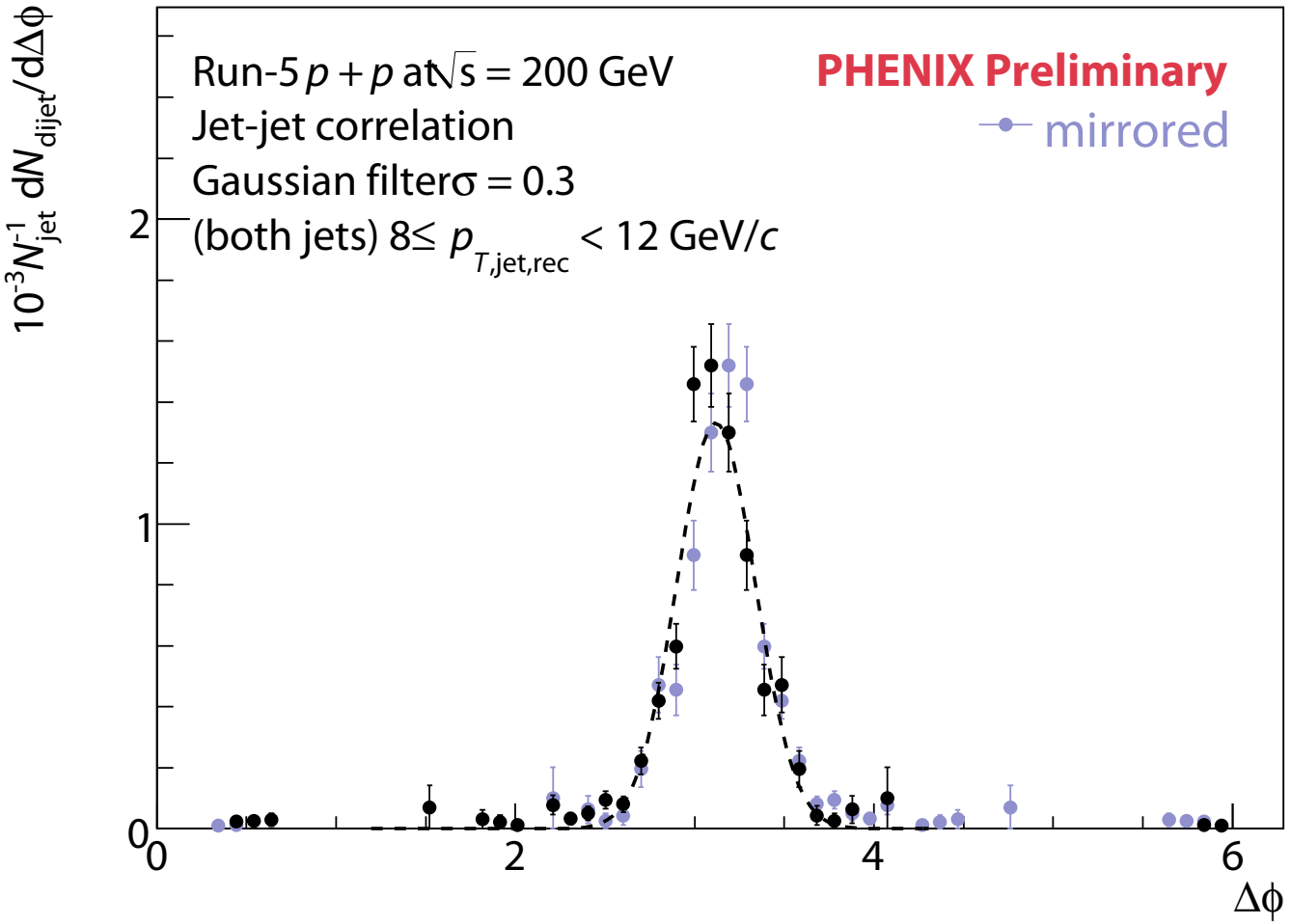
- Gaussian fit: mean $= 3.107\,8(92)$, $\sigma = 4.186(10)$

Jet–jet correlation, symmetric $6 < p_{T,\mathrm{jet,rec}} < 8\ \mathrm{GeV}/c$



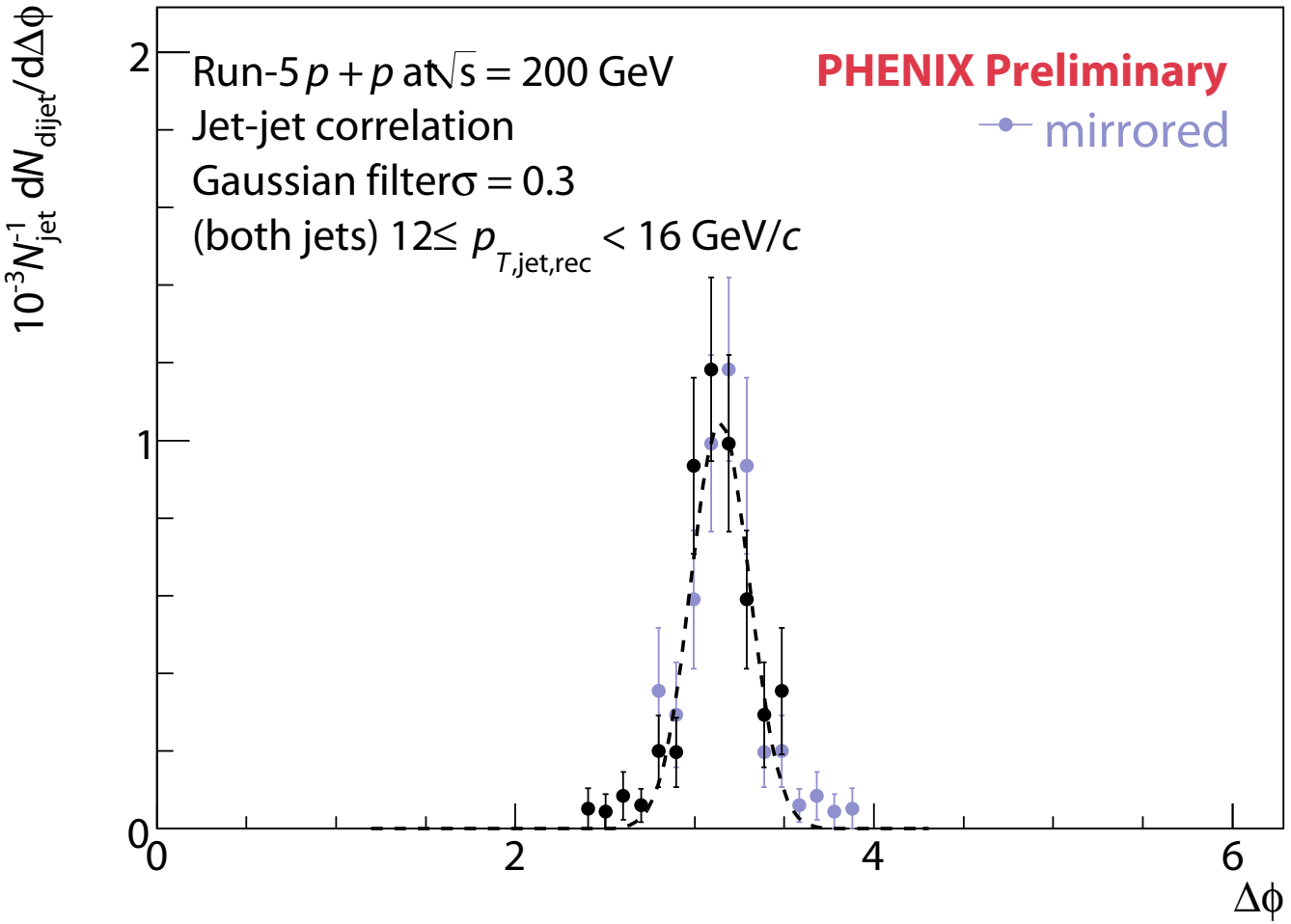
- Gaussian fit: mean $= 3.107\,6(98)$, $\sigma = 2.819\,6(95)$

Jet–jet correlation, symmetric $8 < p_{T,\mathrm{jet,rec}} < 12\,\mathrm{GeV}/c$



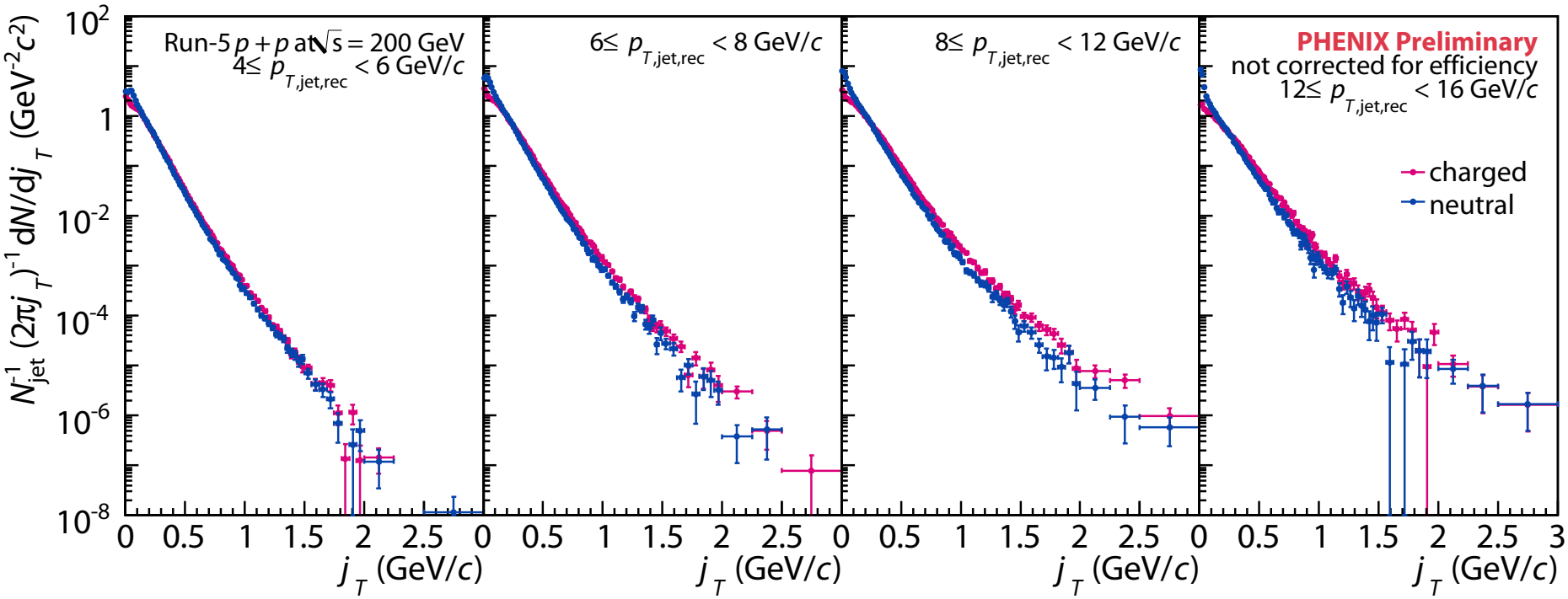
- Gaussian fit: mean $= 3.118\,9(92)$, $\sigma = 2.185\,8(87)$

Jet–jet correlation, symmetric $12 < p_{T,\text{jet,rec}} < 16\ \text{GeV}/c$



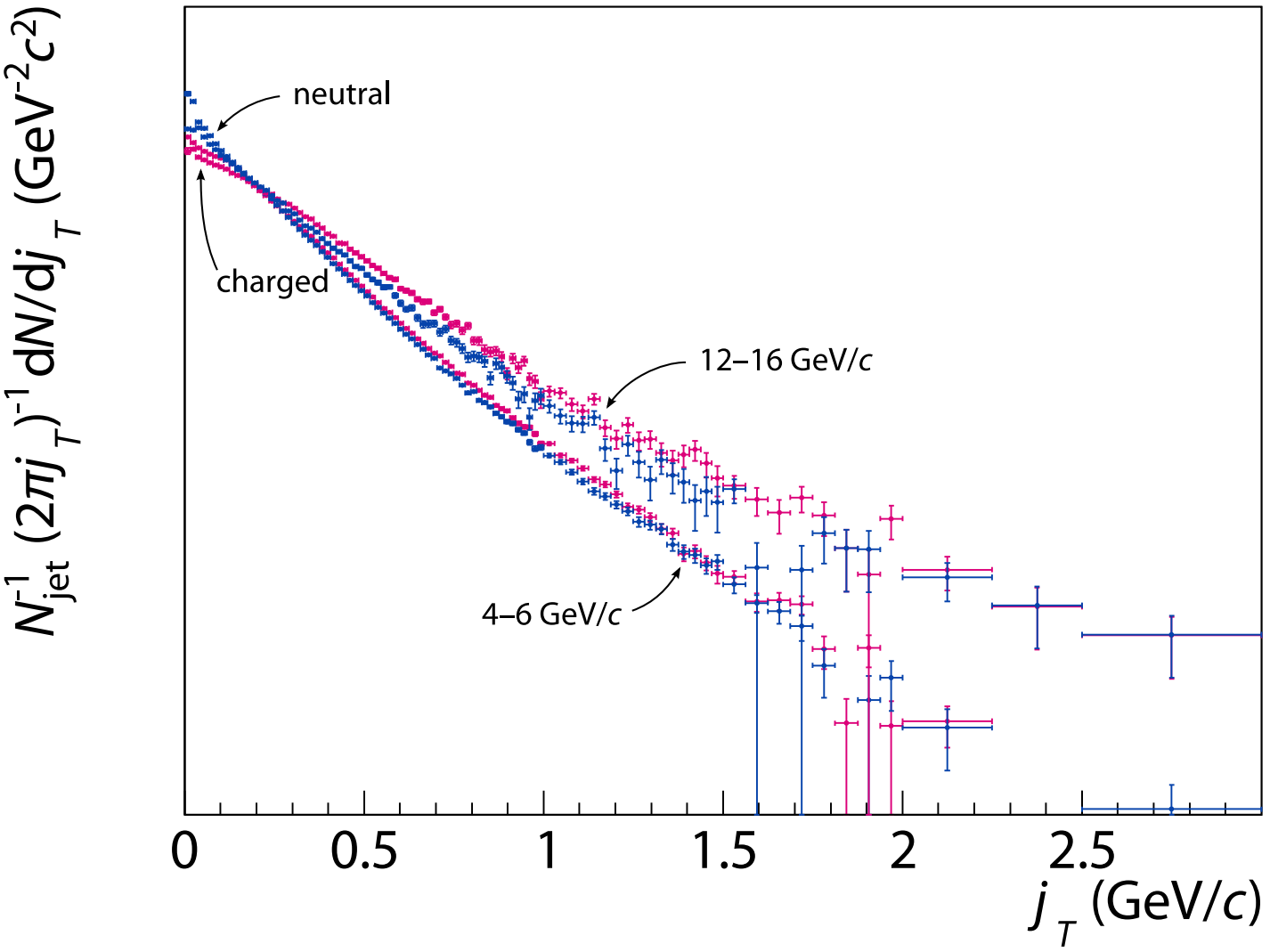
- Gaussian fit: mean $= 3.141(20)$, $\sigma = 1.636(25)$

Fragment j_T distribution



- Non-perturbative component uniform across all p_T range
- Difference in slope due to Seagull effect

Fragment j_T distribution, 4–6 vs. 12–16 GeV/c



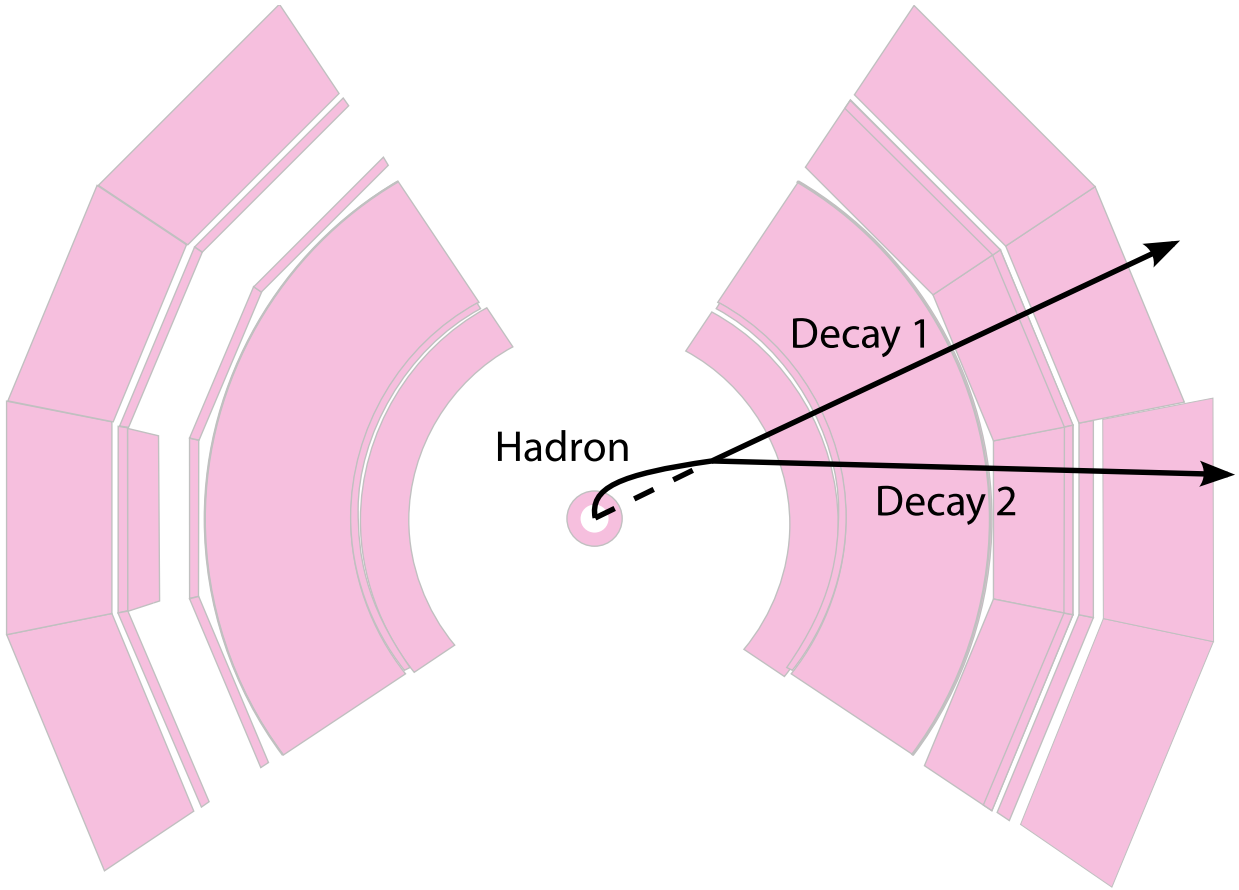
Summary

- Gaussian filter as a jet reconstruction algorithm insensitive to large angle distortion – either acceptance limit or heavy ion fluctuation
  - First application on PHENIX
- PHENIX acceptance limit does not hinder jet reconstruction or 2π-azimuthal jet variable
- Jet spectrum and fragmentation will be available soon, after completing the detector simulation
- Cu + Cu, Au + Au results are underway

Part I

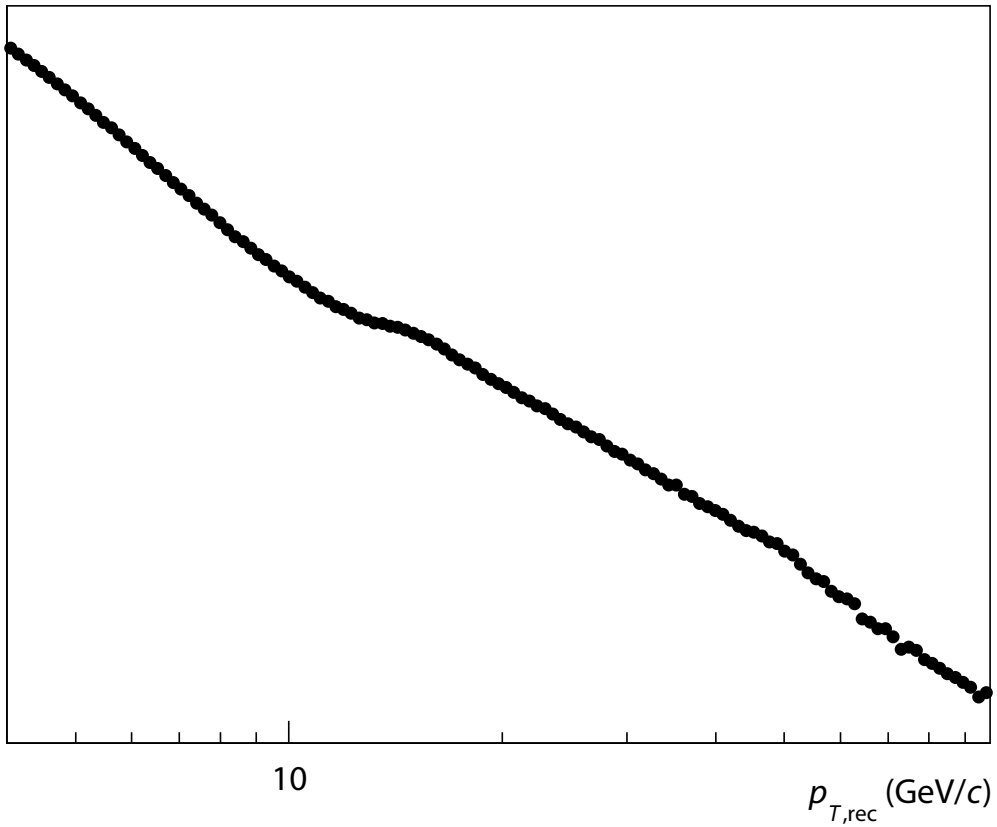
Backup

Conversion tracks



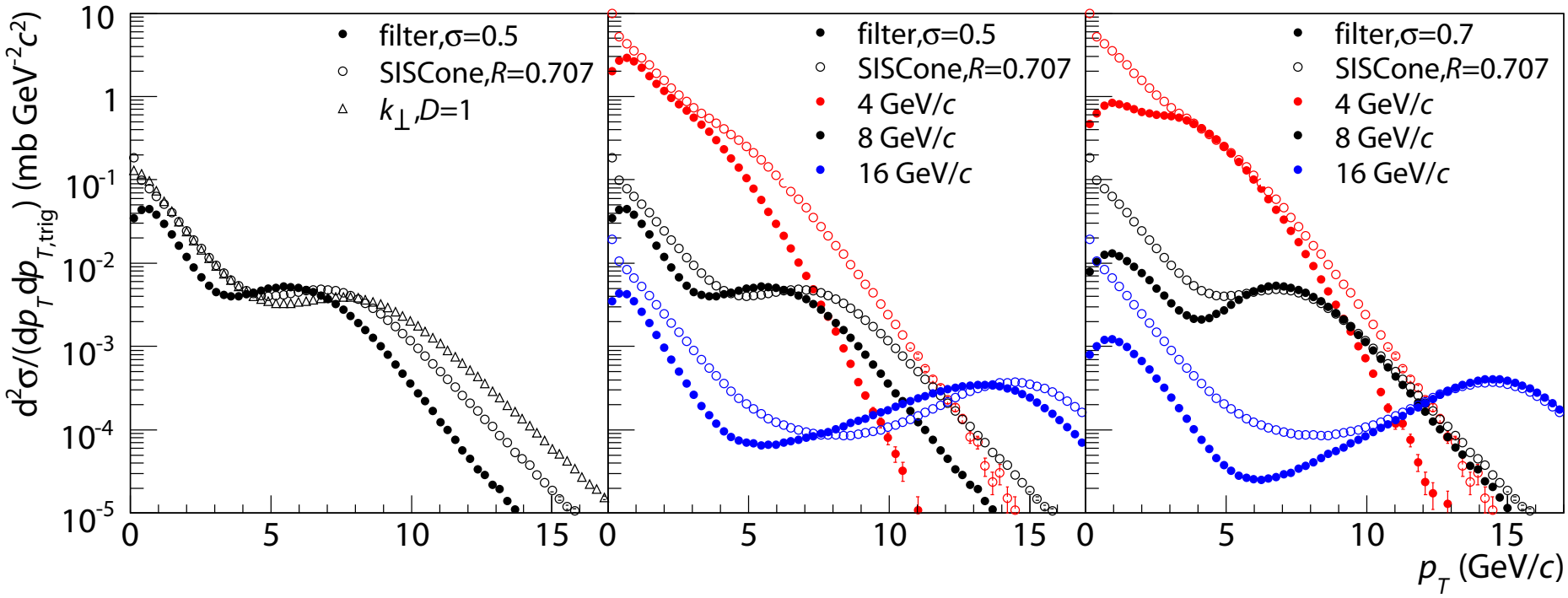
- Track p_T misreconstruction due to early decays

Uncorrected $p_{T,jet}$ spectrum



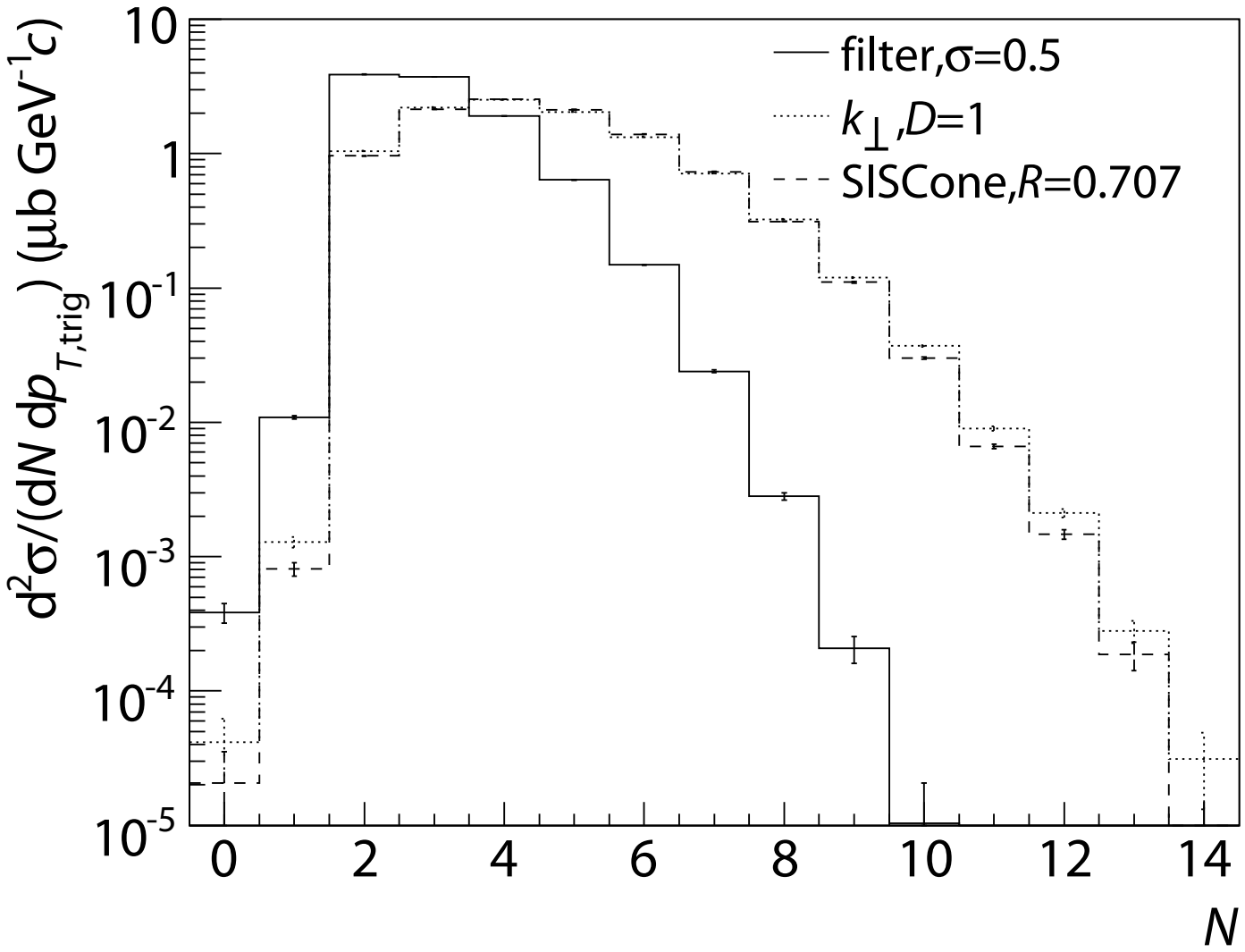
- Full detector trigger and p_T scale effect
- Residual non-linearity is expected to go away with proper trigger efficiency and p_T correction

PYTHIA triggered p_T spectrum, filter vs. SISCone vs. $k_\perp$



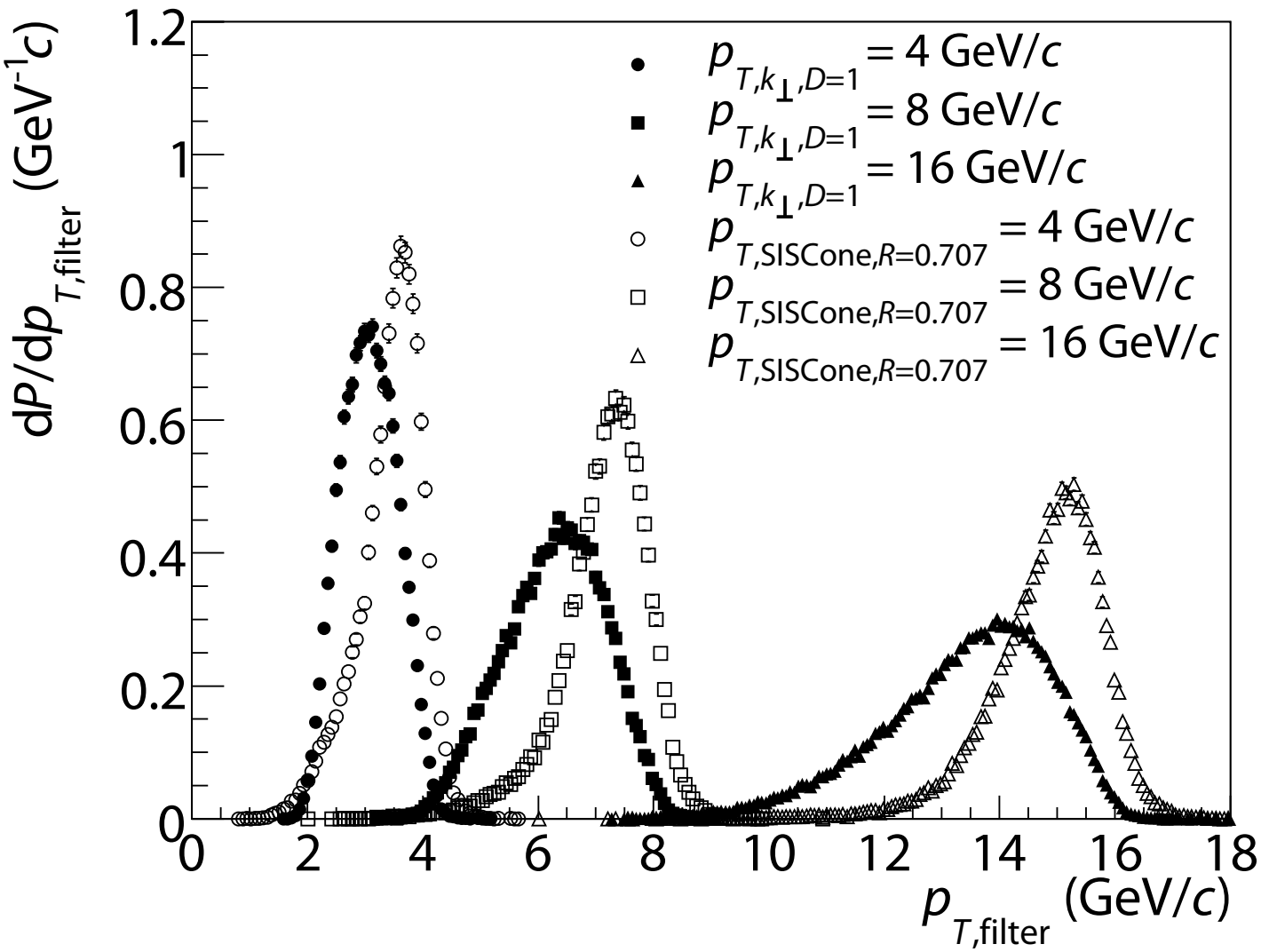
- arXiv:0806.1499, fig. 4

PYTHIA jet multiplicity, filter vs. SISCone vs. $k_\perp$



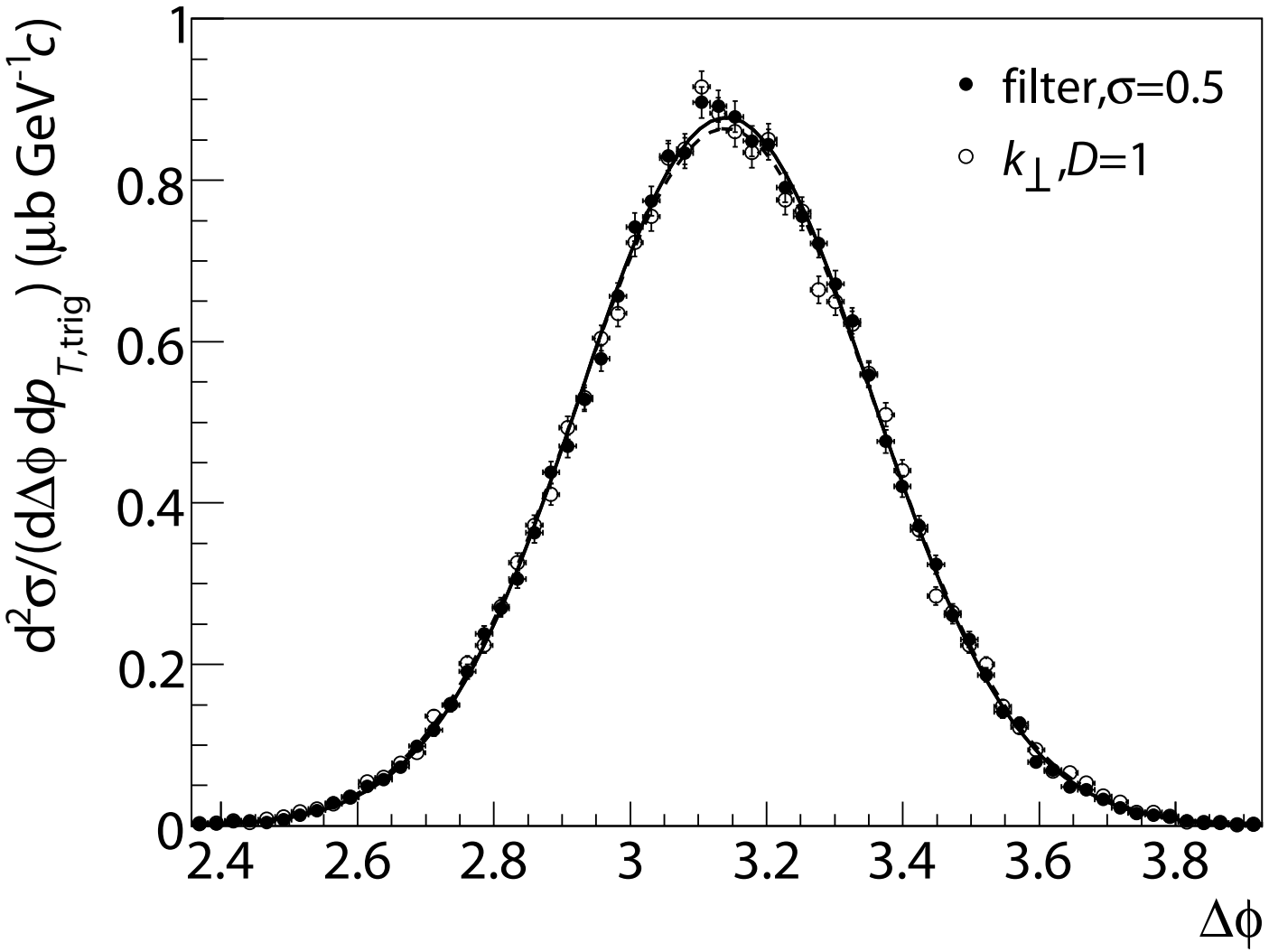
- arXiv:0806.1499, fig. 3

PYTHIA p_T scale, filter vs. SISCone vs. $k_\perp$



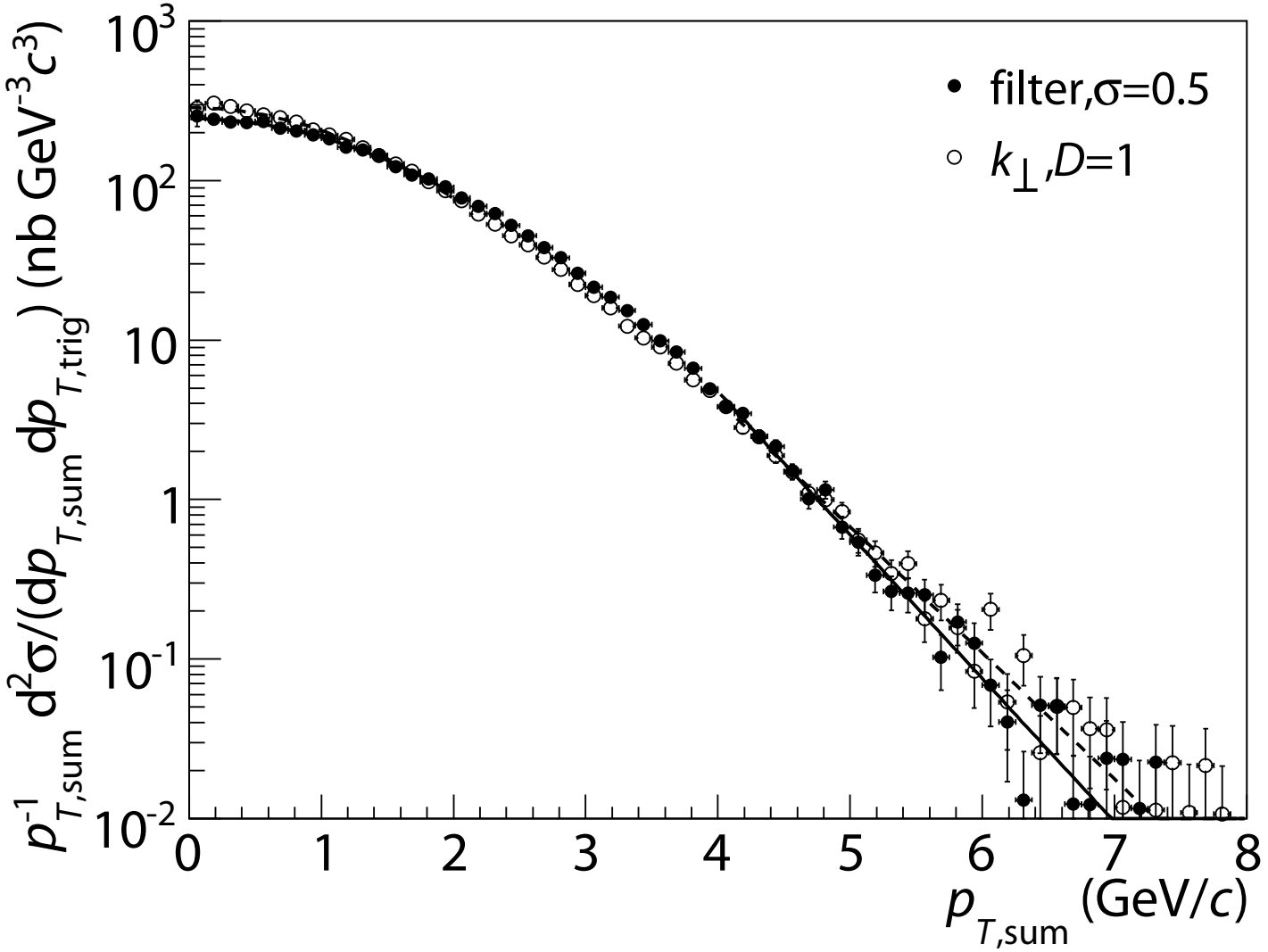
- arXiv:0806.1499, fig. 2

PYTHIA dijet angular balance, filter vs. $k_\perp$



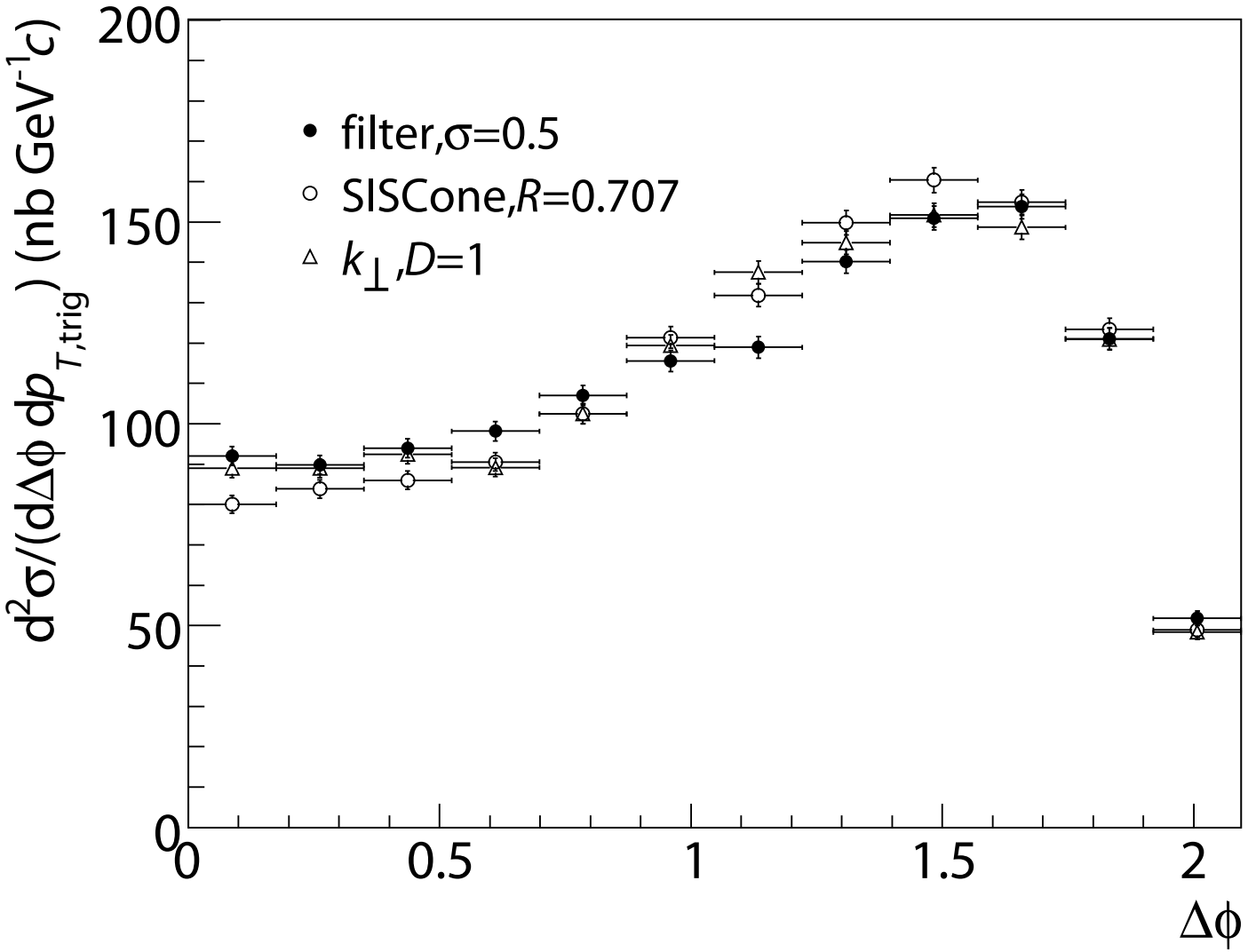
- arXiv:0806.1499, fig. 5

PYTHIA dijet p_T balance (p_T scale normalized), filter vs. $k_\perp$



- arXiv:0806.1499, fig. 6

PYTHIA 3 jet angular distribution, filter vs. SISCone vs. $k_\perp$



- arXiv:0806.1499, fig. 7